International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN (P): 2249-6890; ISSN (E): 2249-8001
Vol. 8, Issue 1, Feb 2018, 105-110

PARAMETRIC ANALYSIS AND EFFECT OF TOOL ON FSW JOINT OF 6082 AL ALLOY BY TAGUCHI METHOD

VIVEK JOHN, RUBY PANT, SAURABH AGGARWAL & PIYUSH AGRAWAL

Assistant Professor, Uttaranchal University, University in Dehradun, India

ABSTRACT

The Friction-stir processing is an emerging technology of plastic deformation that is based on friction stir welding (FSW). In friction stir welding, in order to get a defect free processed zone, the tool is considered to be very significant. The shoulder of the tool, which is considered as the main source of heat generation, is of two different shapes flat or tapered. Friction stir Welding is the type of welding used as a solid state joining process (below melting point), for materials that is different alloys of aluminum, magnesium etc. and also, for hard materials like steels. The effects of various parameters of the FSW welding process like rotational speed, depth of cut, feed rate, probe diameter, shoulder diameter, welding speed have been investigated to reveal their Impact on welding joint, using Taguchi Methodology. Experimental plan is performed by a Standard Orthogonal Array. The results of analysis of variance (ANOVA) indicate that, the proposed mathematical model can be adequately describing the performance, within the limit of factors being studied. This paper deals with wear characteristics during FSW, at different tool materials at different process parameter of Aluminum alloy 6082. Different Welded samples are prepared with different rotational speed, welding speed and shoulder diameter. Taguchi is applied to optimization.

***KEYWORDS**: FSW, Orthogonal Array, DOE & Anova.*

Received: Nov 03, 2017; **Accepted:** Nov 24, 2017; **Published:** Dec 23, 2017; **Paper Id.:** IJMPERDFEB2018012

Original Article

INTRODUCTION

First in the year of 1991 from the welding institute in the USA, Mr. Thomas Friction stir welding (FSW) is developed and patent [1]. Friction stir Welding is the type of welding used as a solid state joining process (below melting point), for materials that is different alloys of aluminum, magnesium, etc. and also for hard materials like steels because, it avoids the common problems obtained in conventional welding process [2]. It is very efficient and environment friendly. Aluminium alloy is used in various fields, due to their properties and light weight, aluminium has various alloys series, 2xxx and 7xxx series are difficult to weld, because of their properties of poor solidification and porosity infusion zone, hence Aluminium alloys are easy to weld by FSW. [2] There are difficulties in conventional welding processes like formation of porosity, solidification cracking, and chemical reaction, during welding of dissimilar materials.[3] Due to these reasons, joining of alloys could be usually facing problems, in many sectors that includes automotive, aerospace, ship building industries, electronics, etc.[5] where conventional fusion welding is not possible, due to their large difference in physical and chemical properties of the base metals to be joined.

Table 1: Chemical Composition of Al6082

Element	Si	Fe	Cu	Mn	Mg	Zn	Ti	Cr	Al
Percentage	0.7-1.3	0.0-0.5	0.0-0.1	0.4-1.0	0.6-1.2	0.0-0.2	0.0-0.1	0.0-0.25	Balance

In FSW process, material is fixed on bed that is going to be joined, with the help of clamp and fixtures. A non consumable rotating tool is used, which rotates over the plate which is going to be joined. Due to that, rotation friction heat is produced in between two materials, which brings the material in semi solid state, and due to that rousing action and pressure by the tool the semi-solid material gets joined [3].

Won-Bae et al. studied the microstructures and wear property of Friction stir welded AZ91 Mg Alloy/ Sic particles reinforced composite. They found an improvement in the wear property of the weld zone, as compared to base metal. They concluded the wear resistance within the weld zone, as elevated by the specific wear loss, was superior as compared to the base metal [6]. Dina- haranl et al. developed an empirical relationship, to predict the effect of process parameter on sliding wear behavior of Butt joints of friction stir weld AA6061/0-10 wt. % ZrB2 composites. They concluded that, wear rate decreases as tool rotational speed, welding speed and axial forces increase. After that, further increase in these process parameter increases the wear rate [7]. Prakash et al., studied the tribological behavior i.e. dry sliding wear characteristics using a computer aided pin on disc wear testing machine of friction stir process Al 6061 sheet, with metal reinforced. They concluded that, wear rate decreased as weight percentage of Al2O2 increased [8]. Palanivel et al., developed an empirical relationship between FSW process parameter and wear resistance of friction stir welded joints of dissimilar Aluminium alloysAA5083-AA6351. It was found that, wear resistance increases as tool rotation speed, welding speed and axial force increases up to a certain level, then it starts decreasing [9]. Fernandez et al. studied the FSW of cast Al 359/ 20% SiC composite. They focused on the effect of FSW tool rotational speed and weld speed, for reducing the tool wear rate. The result indicated that minimum wear obtained with the lowest tool rotational speed [10]. Prater et. al., characterized the tool wear in FSW of A359/20%SiC MMC, by varying process parameters. It was also observed that, with increase in the welding speed, the ultimate tensile strength of the joint decrease [11]. Mishra et.al., address that tool wear and shape optimization are associated, with the tool material and further research is needed for selection of tool material [12]. As it has been noted that, a production of quality needs a selection of the appropriate tool material with a correct parameters, for a specific application. Thus, it is unusable to have a tool that has less dimensional stability [6]. Lots of researchers have discussed about different conditions, for the selection of tool materials. Although, there are some researchers who have selected the tool materials, based on literature, but this not precise. Perhaps it has been noted for production of a quality welding needs appropriate selection of the tool material, for a specific application. Thus, it is unsuitable to have a tool that has poor dimensional stability. Finally, from the literature, it can be summarized that, defects produced in welding and defects in any welded part can come up, due to improper selection of process parameters or wear of the welded part. From the entire above conclusion, there is a need to select a proper tool material and process parameters, to upkeep wear or to keep this wear for defect free welding.

EXPERIMENT DETAILS

In the present study, Al 6082 plates are used as a work material, having dimension of 30 mm thickness, 70 mm width and 280mm long. HSS tool was used for the welding with different rotational speed, different welding speed and different shoulder diameters. The welding was done using a FSW process. The work piece specimen was tested under different welding speed and shoulder diameter with different rotational speed. Experiments are designed with the help of us-

ing Taguchi orthogonal array. The Minitab 16 software is used, to design and analyze the parameters for effective optimized results.

Table 2: Control Parameters at their Various Levels

Factors	Level 1	Level 2	Level 3
Welding Speed(rpm)	800	900	1000
Rotational Speed(mm/min)	25	35	45
Shoulder Diameter (mm)	14	16	18
Wear*10^{-5}(mm^3/min)	34	35	25

RESULT AND CALCULATIONS

Table 3: Main Table of Experiment

Welding Speed (rpm)	Rotational Speed (mm/min)	Shoulder Diameter (mm)	Wear x 10^5 (mm^3/min)	SNRA	MEAN
800	25	14	34	30.629	34
800	35	16	35	30.881	35
800	45	18	25	27.958	25
900	25	16	29	29.247	29
900	35	18	34	30.629	34
900	45	14	24	27.604	24
1000	25	18	23	27.234	23
1000	35	14	33	30.370	33
1000	45	16	28	28.943	28

Table 4: Response Table for Means

Level	Welding Speed	Rotational Speed	Shoulder Diameter
1	31.33	28.67	30.33
2	29.00	34.00	30.67
3	28.85	25.67	27.33
Delta	3.33	8.33	3.33
Rank	3	1	2

The table 4 indicated that Rotational Speed is the most significant factor and is ranked first followed by Shoulder Diameter followed by Welding Speed.

Table 5: Analysis of Variance for Wear

Source	DF	Seq SS	AdjSS	AdjMS	F	P
Welding Speed	2	17.56	17.56	8.78	0.52	0.65
Rotational Speed (rpm)	2	106.89	106.89	53.44	3.19	0.02
Shoulder Diameter	2	20.22	20.22	10.11	0.60	0.62
Error	2	33.56	33.56	16.78		
Total	**8**	**178.22**				

From the table 5, it is also found that the factor Rotational speed is found significant with the P value of 0.02.The comparison of F value of table 5 with the suitable F value of the factors for 95% confidence level respectively depicts that the factor Rotational speed is significant. Figure1 shows the effect of the each level of the three factors on wear for the mean value of measured wear at each level for all the 09 runs.

Table 6: Response Table for Signal to Noise Ratios

Level	Welding Speed (A)	Rotational Speed (B)	Shoulder Dia (C)
1	-29.82	-29.04	-29.53
2	-29.16	-30.63	-29.69
3	-28.85	-28.17	-28.61
Delta	0.97	2.46	1.08
Rank	3	1	2

From Table 6, Optimal Parameters for Tuning Operation were A2, B3, and C3. The difference of SNR between level 1, 2 and 3 indicates that Rotational Speed contributes highest effect (Δmax - Δmin = 2.46) followed by Shoulder Diameter (Δmax - Δmin = 1.08 and Welding Speed (Δmax - Δmin = 0.97).Therefore, the predicted value of S/N Ratio for turning operation is

η_p**(Wear)= -29.28+[(-29.16-(-29.28]+[-29.16-(-29.28)]+[-28.61-(-29.28)] =-28.37**

Table 7: ANOVA Table for Wear Vs Welding Speed

Source	DF	SS	MS	F	P
Welding Speed	2	17.6	8.8	0.33	0.733
Error	6	160.7	26.8		
Total	**8**	**178.2**			

Table 8: ANOVA Table for Wear Vs Rotational Speed

Source	DF	SS	MS	F	P
Rotational speed	2	106.9	53.4	4.50	0.05
Error	6	71.3	11.9		
Total	**8**	**178.2**			

Table 9: ANOVA Table for Wear Vs Shoulder Diameter

Source	DF	SS	MS	F	P
Rotational speed	2	20.2	10.1	0.38	0.697
Error	6	158.0	26.3		
Total	**8**	**178.2**			

From the Annova tables 7, 8 and 9, which are comparing wear with welding speed, Rotational speed and shoulder diameter, it also clear that, rotational speed is found to be significant with the P value of 0.05.

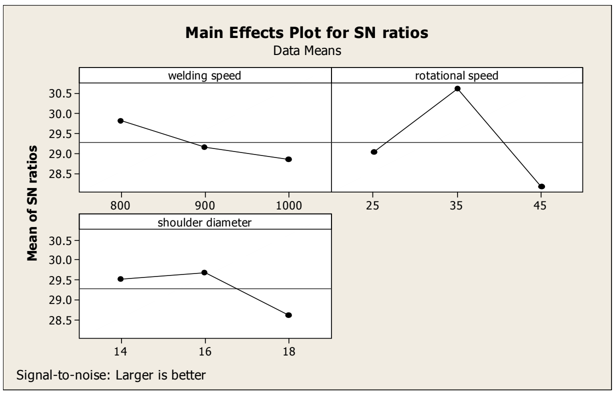

Figure 1:Main Effects Plot for SN Ratio

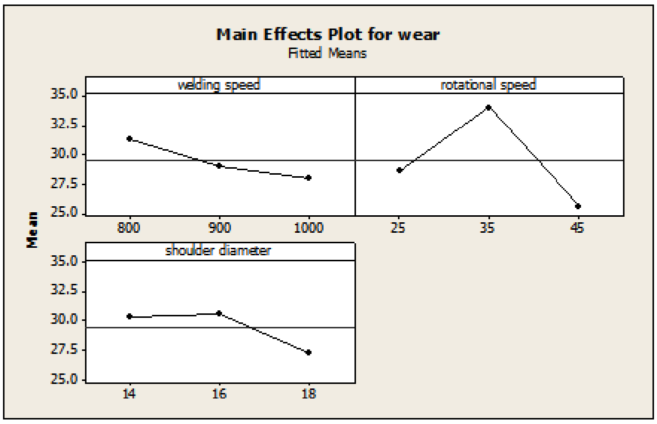

Figure 2: Main Effectsplots for Wear

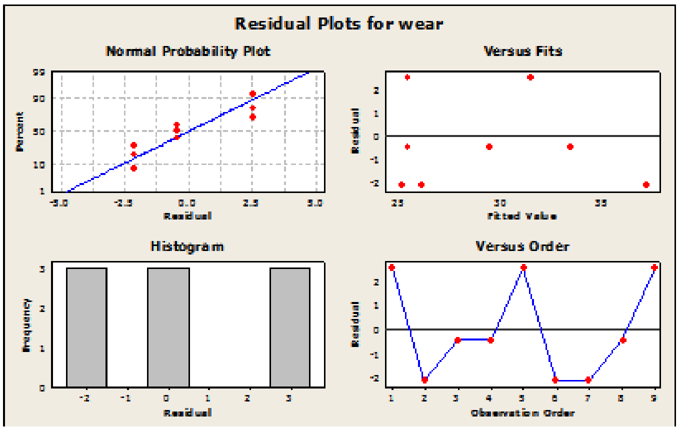

Figure 3: Residual Plots for Wear

DISCUSSIONS

From the table 3.1, optimal parameters for wear are Second level of Welding Speed (900 rpm), third level of Rotational Speed(45 mm/min) and third level of Shoulder diameter(18 mm)

CONCLUSIONS

The Optimization of the control input parameters was done using Taguchi method and the optimal value was predicted using a predictive equation. All the results attained by the present work can be used to achieve minimum wear.The present research work can be done along with all possible chodsen interactions, among the different levels of the parameters, in order to expand the study.

REFERENCES

1. *Thomas WM. Nicholas ED, Needhan JC, Murch MG, Temple smith (1991) International patent application PCT/GB92/02203 and GB patent application no. 9125978.9.*
2. *Mishra R. S et al Friction stir welding and processing, Material Science and Engineering R 2005: 50:1-78.*
3. *Karam A, Mahoud T. S, Zakaria H. M, Khalifa T. A, Friction stir welding of two dissimilar A319 and A413 Cast aluminium alloys. Arabian journal for Science and Engineering 2014; 39:6363-6373, http://dx.doi.org/10.1007/s13369-014-1220-6.*

4. *S. Krishnakumar et al., Evaluation of Machinability of D2 Steel using Cryo Treated Cermet using Taguchi Technique, International Journal of Mechanical and Production Engineering Research and Development (IJMPERD), Volume 7, Issue 3, May - June 2017, pp. 7-16*

5. *Lofti Amir Hossein, Nourouzi Salman, Effect of welding parameters on microstructure thermal and mechanical properties of friction stir welded joints of AL7065-T6 aluminium alloy, Metallurgical and Material Transaction A2014:45a:2792-2807.*

6. *Veerendra, Keshavamurthy R, Prakash CPS. Microstructure and Hardness distribution in friction stir welded Al6061-TiB2 in metal matrix composite 2014, 2(9).73-6 .IRAj doi.IJMPE-IRAJ-DOI-1240.*

7. *Debashis Dey et al., Optimization of the Tool Parameters in Ultrasonic Vibration Assisted Drilling by Taguchi Method, International Journal of Mechanical and Production Engineering Research and Development (IJMPERD), Volume 6, Issue 1, March - April 2016, pp. 6-2*

8. *Lee Won- Bae, Kim Myoung-Kyun, Kim Young-Jig, Microstructures and Wear property of friction stir welded AZ91Mg/SiC particle reinforced, Composite Science and Technology 2006:66:1513-1520.*

9. *Dianharan I, Murugan N, Influence of friction stir parameters on sliding wear behavior of AA6061/0-10 wt% ZrB2 in-situ composite butt joints, Journal of Minerals and Materials Characterizations and Engineering 2011:10(14):1359-1377, http://dx.doi.org/10.4236/jmmee.2011.1014107.*

10. *Prakash T, Sivasankaran S, Sasikumar P, Mechanical and Tribological behavior of friction stir processes Al6061 aluminum sheets metal reinforced with Al2O3, Arabian Journal for science and Engineering 2015;40:559-569, http://dx.doi.org/10.1007/s 13369-014-1518-4.*

11. *Avinash, Kailash B Anwar & Gowreesh, Optimization of Diesel Engine Parameters with Blend of Pongamia Biodiesel and Diesel Using Taguchi Method, International Journal of Applied Engineering Research and Development (IJAERD), Volume 5, Issue 1, January - February 2017, pp. 13-20*

12. *Palanivel R, Mathews P. Koshy, Murugan N, Prediction and optimization of wear resistance of frictuion stir welded dissimilar aluminium alloy, Procedia Engineering 2012; 38:578-584, http://dx.doi.org/10.1016/j.procng.2012.06.072.*

13. *Fernandez GJ, Murr LE. Characterization of tool wear and weld optimization in the friction stir welding of cast aluminium 359+20% SiC metal matrix composite. Mater Charact 2004;52:65-75, http://dx.doi.org/10.1016/j.matchyar.2004.03.004.*

14. *Prater T. Friction Stir welding of metal matrix composite for use in aerospace Structures. Acta Astronaut 2014;366-73, http://dx. doi.org/10.1016/j.actaastro.2013.07.023.*

15. *Mishra RS, Mahoney MW. Friction stir welding and processing, production processes and systems. Mater SCI Eng Rep 2007;6(1):6-1*